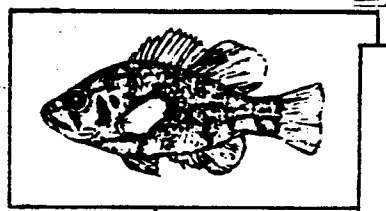
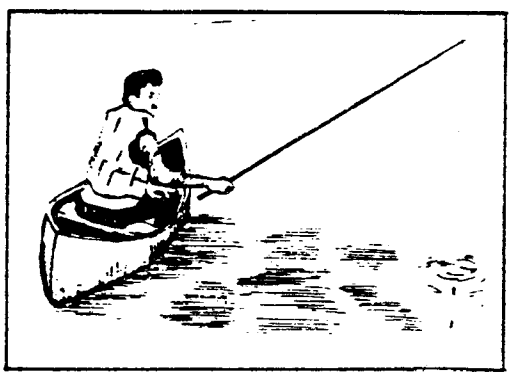
FLOYDS FORK DRAINAGE BIOLOGICAL AND WATER QUALITY INVESTIGATION FOR STREAM USE DESIGNATION

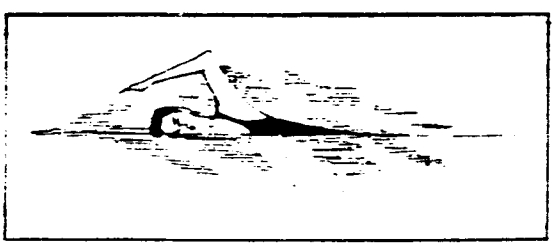
Outstanding Resource Waters



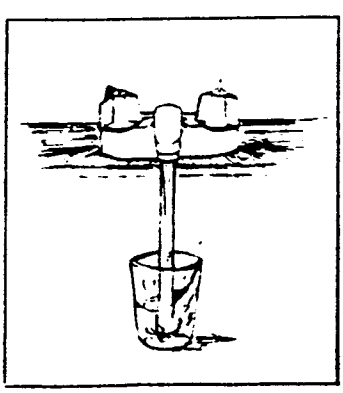
Aquatic Life



Recreation



Natural Resources and Environmental Protection Cabinet



Domestic Use

Division of Water
Biological Section
Technical Report No. 3

Floyds Fork Drainage
Biological and Water Quality Investigation
for Stream Use Designation

Kentucky Department for Environmental Protection
Division of Water
Biological Section

Frankfort, Kentucky

Technical Report No. 3

December, 1986

This report has been approved for release:

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Abstract

A biological and water quality investigation of the Floyds Fork drainage was conducted in November, 1981 to determine the existing water quality, aquatic uses currently being achieved, causes of impairments of aquatic uses and what aquatic uses can be attained based on the physicochemical and biological characteristics of the system. Of the 164 miles of the Floyds Fork system which are listed on the United States Geological Survey's hydrologic map, 51 miles of the Floyds Fork System is not supporting designated uses, 77 miles are considered to be partially supporting uses and 12 miles are unknown.

The Floyds Fork drainage lies within the Outer Blue Grass physiographic region in Jefferson, Oldham, Henry, Shelby and Spencer counties and enters the Knobs Subsection of the Blue Grass in Bullitt county. The stream segments are used for primary and secondary contact recreation. The basin contains substantial, diverse warmwater aquatic habitat as reflected by the aquatic flora and fauna. However, the aquatic biota has been adversely impacted in Chenoweth Run (segment 26) and in areas downstream from its confluence with mainstem Floyds Fork. The primary impact to the basin is the discharge of wastewater effluents (103 point source discharges). Agricultural and urban runoff are secondary impacts to the drainage. Kentucky Surface Water Standards have been violated for dissolved oxygen, pH, phthalate esters, cadmium, aluminum, iron, mercury and undissociated hydrogen sulfide. It is recommended that Floyds Fork and its tributaries be classified under 401 KAR 5:031, Section 4 (1) for aquatic life/warmwater aquatic habitat and Section 6 for recreational waters/primary and secondary contact recreation and the criteria in these sections be applied throughout the segment without modification. Data from this study indicate that these uses are currently occurring, or are attainable with the application of appropriate point source pollution control technologies. It is anticipated that non-point sources will not affect the attainability of these uses. No surface withdrawals for domestic water supply occur in the drainage.

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RECOMMENDATIONS

1. Based on the diversity of aquatic organisms, it is recomended that the entire Floyds Fork subbasin (segments 12025, 12026, 12027, 12027, 12028) be designated for Aquatic life/Warmwater Aquatic Habitat per 401 KAR 5:031 Section 4, and the criteria of that section be applied without modification.

2. Based on the determination that fecal coliform criteria are attainable in Segments 12025, 12027, 12028, it is recommended that those segments be designated as Recreational Waters/Primary Contact Recreation per 401 KAR 5:031 Section 6 and the criteria of that section be applied without modification. Segment 12026 is recommended for Secondary Contact recreation, based on the number of WWTP discharges in the segment.

3. Since no surface withdrawals of public drinking water occur in any segments, that use is not recommended.

SUMMARY

1. Floyds Fork, a fifth order stream, flows 99 km (62 mi) through portions of Henry, Oldham, Shelby, Jefferson, Spencer and Bullitt counties. It drains an area of 736 km^2 (284 mi^2).

2. Using the United States Geolaogical Survey's hydrologic map (164 total miles), data from this and other studies indicate that 51 miles of the Floyds Fork System are not supporting designated uses, 77 miles are partially supporting uses, 24 miles are supporting uses and 12 miles remain undetermined.

3. Several violations of Kentucky Surface Water Standards (KSWS) (401 KAR 5:031, Sections 4 and 6) were observed during this study and by the Louisville and Jefferson County Department of Public Health (JCHD), and U.S. Geological Survey (USGS). The Water Quality Advisory Board (WQAB) observed one violation. Listed below are the parameters that were in violation according to basin segment.

   Segment 025: Hg, Al, phthalate esters, Cd, DO, pH, H_2S, Fe

   Segment 026: pH, phthalate esters, Hg, Al

   Segment 027: Hg, Al, DO, Fe, Cd, H_2S

   Segment 028: Hg, Cd, Al, DO, Fe, H_2S

4. The EPA recommended acute protection criteria levels were exceeded for the following parameters:

   Segment 025: Cd, Cu, Pb

   Segment 026: Cd

   Segment 027: Cd, Cu, Pb

   Segment 028: Cd

5. The U.S. EPA recommended chronic protection criteria levels were exceeded for several parameters, listed below by segment.

   Segment 025: Hg, Cd, Pb, Zn, Ni

Segment 026: Hg, Pb

Segment 027: Hg, Pb, Zn, Ni

Segment 028: Hg, Cd, Pb

6. Sediments were found to be contaminated with heavy metals and pesticides in several locations. These parameters are listed below by segment.

Segment 025: heavily polluted with arsenic and moderately polluted with chromium, lead and zinc. Detectable quantities of PCP were also present.

Segment 026: heavily polluted with arsenic and lead and moderately polluted with cadmium, chromium, copper and zinc. Detectable quantities of chlordane and PCP were present.

Segment 028: heavily polluted with arsenic and lead and moderately polluted with cadmium and chromium. Detectable quantities of PCP were present.

7. Values for conductivity, pH, Cl^-, F^-, $SO_4^=$ and $NO_2 + NO_3$ - N for Chenoweth Run (026) were the highest observed in this study. The $NO_2 + NO_3$-N may result in downstream nutrient enrichment problems.

8. Data collected by the JCHD and USGS from various sites in the drainage indicate frequent violations of KSWS primary contact criteria for fecal coliform (FC) bacteria during the recreation season (May 1 to October 1). No violations of the FC standard were observed during this study, probably because of the time of year the samples were taken (November). The probable source for the human fecal pollution is (1) improperly operating sewage treatment plants and (2) septic tank infiltration.

9. A total of 103 Wastewater Treatment Plant (WWTP) point source discharges are present in the Floyds Fork drainage. Two of these plants have been a constant source of problems. The Lakewood Valley Subdivision WWTP was cited 17 times between November 18, 1977 and March 20, 1980 for not properly chlorinating their effluent. It has also been cited three times for

bypassing raw sewage directly into the stream; one of those events resulting in a fishkill. The Ash Avenue Sewer Company effluent has consistently had FC values well above KSWS criteria. A lift station associated with the plant has bypassed raw sewage to an unnamed tributary to Floyds Fork and the company has been involved in litigation for several years. These facilities represent a known threat to public health and primary contact recreation.

10. McNeely Lake, a 53 acre hypereutrophic reservoir, is functionally a large "polishing lagoon" for WWTP effluents in the Pennsylvania Run subbasin.

11. Stream habitats were diverse throughout the Floyds Fork system. Pools and riffles were common, as well as rock ledges, undercut banks, gravel bars, root mats, shoals, brush covered islands, log piles, submerged logs and roots, and a variety of substrates. Riparian vegetation was generally well developed and provided shade, bank stability, sediment and nutrient control, as well as food and cover for fish, invertebrates and wildlife.

12. A total of 263 algal taxa were encountered in the drainage, dominated by species characteristic of nutrient rich, highly oxygenated, flowing waters. Elevated water column nutrient concentrations have stimulated dense growths of filamentous algae, which have created localized nuisances and concurrent degradations in water quality. Physiological stress (frustular aberrancy) was noted in several diatom species at sites known to be impacted by certain heavy metals.

13. A total of 139 taxa of aquatic macroinvertebrates were collected from the drainage, with adverse community impacts noted in and downstream of Chenoweth Run (26-1). A core of tolerant species was consistently present at each site.

14. After extensive sampling of available habitats, a total of 18 mussel species were collected from the drainage, although 13 of those species were found

only as relic shells. Mussel recruitment was not apparent at any site in this study.

15. Floyds Fork has a diversity of habitats which is reflected in its fish fauna. A total of 46 fish species are known from the drainage, including numerous darters and minnows. A total of 37 species were collected in this study. Although some areas of the stream appear to be organically enriched, the fish communities do not seem to be adversely affected. A sport fishery existed at all sites sampled. Sport fish included bass (largemouth, spotted and rock), bluegill and redear sunfish. Fish tissue analysis in segment 027 indicated detectable levels of certain metals and organic compounds (Appendix F) although (FDA) action levels were not exceeded. The trout perch Percopsis omiscomaycus, listed by the Kentucky Nature Preserves Commission - Kentucky Academy of Science as being of special concern, was collected in the upper portion of the Floyds Fork system.

16. Floyds Fork has been cited in the Nationwide Rivers Inventory (National Park Service 1982) as having outstanding scenic, recreational, geological and fishery values. The stream's recreational and scientific benefits are of added significance because of its proximity to the largest metropolitan area in the state (Louisville). The watershed is currently supporting a diversity of habitats for aquatic flora and fauna.

INTRODUCTION

This document presents the results of an investigation directed at the establishment of stream use designation (SUD) for the Floyds Fork system (Figure 1). To establish SUD, a multi-goal approach was utilized. The approach included:

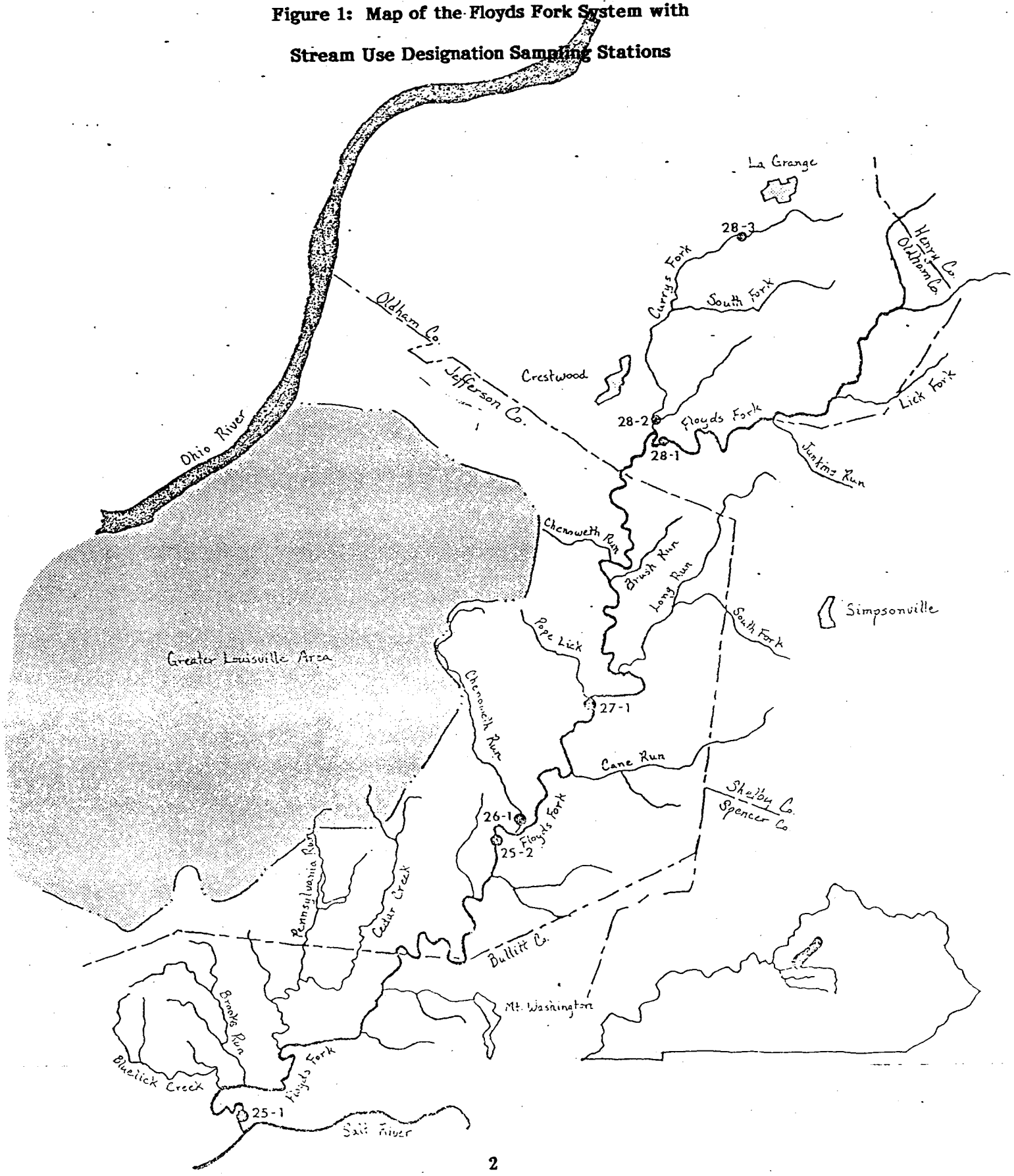
1. Determination of the existing water quality of the Floyds Fork system.
2. Determination of the aquatic uses currently being achieved.
3. Determination of the causes of any impairments in the aquatic uses.
4. Determination of aquatic uses attainable based on the physical, chemical and biological characteristics of the system.

In meeting these goals, a survey of the Floyds Fork system was conducted by the Biological Analysis Section of the Department for Environmental Protection in November, 1981. A total of seven sampling stations were established and sampled during a low flow period. Location of these stations, dates sampled and parametric coverage are given in Appendix A.

The Floyds Fork watershed has been divided into 4 management segments (Schimpeler and Corrandino, Associates 1975). A segment is defined as a portion of a basin, the surface waters of which have common hydrologic characteristics, common natural environmental features, and common external stresses such as discharge of pollutants (Schimpeler and Corrandino Associates 1975). The lowermost segment of Floyds Fork (MP 0.0 to 24.25) is designated 12 (Salt River Basin) 025 (Floyds Fork), a middle segment (MP 24.26 to 47.8) is designated 12027 and an upper segment (MP 49.7 to 66.7) is designated 12028. An additional segment, 12026, includes the Chenoweth Run subbasin.

The United States Geological Survey's (USGS) hydrologic map list a total mileage of 164 miles for the Floyds Fork system. This study, as well as

Figure 1: Map of the Floyds Fork System with Stream Use Designation Sampling Stations



others indicate that 51 miles of the Floyds Fork system does not support designated uses, 77 miles partially support uses, 24 miles are supporting uses and 12 miles remain undetermined.

Literature Review

The water quality, land uses and aquatic use impairments in the Floyds Fork system were discussed in the Kentuckiana Regional Planning and Development Agency 208 Areawide Waste Treatment Plan (KIPDA 1978), as well as by Schimpeler and Corrandino Associates, 1975). Additional water quality data was presented by USGS (1979, 1980, 1981, 1982), Oldham County Soil Conservation District (OCSCD 1981) and the Water Quality Advisory Board (WQAB no date). Taylor (1980) discussed freshwater mussel communities, while Axon et al. (1982) and Henley (1983) presented data on the ichthyofauna at various sites in the Floyds Fork system and limited water quality data for the system.

Basin Impacts

The metropolitan Louisville area has experienced considerable population shifts during the past 20 years, resulting in increased residential development in Bullitt and Oldham counties, as well as suburban Jefferson County. Floyds Fork drains portions of these previously rural areas. This development has led to an increase in point and nonpoint source discharges to the Floyds Fork system.

Tables 1 and 2 summarize the permitted discharge facilities within the watershed. Segments 12025 and 12026 receive the largest inputs of treated effluents from wastewater treatment plants (WWTP), based on design capacity (DOW Wasteload Allocation (WLA) files). Subdivisions contribute 92% of the treated effluent in segment 12025. Brooks Run and the Cedar Creek system (Figure 1) contribute a greater proportion of treated effluent to Floyds Fork than do tributaries which flow through areas of agricultural lands. Nutrients from

Table 1: Summary of Floyds Fork Permitted WWTP Facilities by Segment with Total Design Capacity (GPD) (DOW WLA Files)

	Facility Type					
Segment	Municipal	Subdivision	Small Sewage	Recreational	School	Total
12025	-	23 (3,934,800)	25 (248,650)	-	4 (50,000)	52 (4,233,450)
12026	1 (4,000,000)	2 (244,400)	7 (5,950)	1 (1,500)	-	11 (4,251,850)
12027	1 (75,000)	6 (815,000)	22 (146,250)	-	1 (15,000)	29 (1,051,250)
12028	-	4 (255,000)	6 (69,000)	-	1 (10,000)	11 (334,000)
TOTAL	2 (4,075,000)	35 (5,249,200)	60 (469,850)	1 (1,500)	6 (75,000)	103 (9,870,550)

Table 2: Total Facilities and Design Capacity for Streams within the Floyds Fork Watershed by 303(e) Segments

Segment	Name of Stream	Total WWTP Facilities	Design Capacity (GPD)
12025	Floyds Fork below Chenoweth Run to mouth	6	57,250
	Brooks Run	10	1,060,000
	Cedar Creek	14	1,018,250
	Pennsylvania Run	7	1,090,800
	Tanyard Branch	5	503,800
	Little Cedar Creek	4	470,000
	Wells Run	1	14,000
	Big Run	2	11,000
	Back Run	3	2,350
	TOTAL	52	4,227,450
12026	Chenoweth Run	11	4,251,850
	TOTAL	11	4,251,850
12027	Floyds Fork below MP 46.9 to confluence of Chenoweth Run	11	412,250
	Cane Run	2	1,500
	Pope Lick	5	284,000
	Long Run	1	10,000
	South Long Run	2	43,000
	Brush Run	3	4,000
	Chenoweth Run	5	296,500
	TOTAL	29	1,051,250
12028	Floyds Fork below source to MP 46.9	1	15,000
	Currys Fork	4	24,000
	South Currys Fork	6	295,000
	TOTAL	11	334,000

subdivision WWTPs have caused the accelerated eutrophication of McNeely Lake, impairing fishing and secondary contact recreation (DOW 1982). Treated effluents in segment 12026 are predominantly (94%) of municipal origin, discharged by the Jeffersontown WWTP to Floyds Fork via Chenoweth Run.

Segment 12027, which includes Pope Lick and "lesser" Chenoweth Run, a different stream than that mentioned in segment 12026, is transitional in development between urban and rural land uses, with small sewage dischargers being dominant (Table 1). Pope Lick and "lesser" Chenoweth Run are the major receiving streams in this segment. Ash Avenue Sewer Company at Pewee Valley accounts for 73% of the total permitted discharge in this segment. Point source dischargers upstream of Pope Lick can account for a major portion of the flow in Floyds Fork during extreme low flow periods (USGS 1981, DOW WLA files). Future development within the Jefferson County portion of the Floyds Fork watershed may contribute to additional urban impact to the streams within segments 12025, 12026 and 12027.

Treated effluent loading to Floyds Fork in segment 12028 is small relative to loadings in the three downstream segments. This segment has remained largely rural in nature. The primary source of treated effluent within the segment originates from subdivisions within the Currys Fork watershed. The Lakewood Valley Subdivision WWTP discharges into an unnamed tributary to South Currys Fork. This facility was cited 17 times between November 18, 1977 and March 20, 1980 for not properly chlorinating effluent (DOW files). The facility has been cited three times for bypassing raw sewage directly into the creek; one of these events resulted in a fish kill on November 3, 1981 (DOW files).

Currently under construction are the Gainsborough Subdivision (90,000 GPD) in segment 12025 and the Kentucky Department of Justice-Correctional Institute for Women (50,000 GPD) in segment 12027. Facilities in the planning

stage include: Rolling Hills (12025), Chenoweth Trace (12026), William Newman (12027), Tucker Station Disposal (12027) and the Maverick Estates II (12028).

Nonpoint source impacts to the water quality of Floyds Fork arise from agricultural and urban runoff (KIPDA 1978). Beaulac and Reckhow (1982) discussed various factors which contribute to nonpoint pollution. Land disturbance and intensive fertilization practices increase the potential for soil erosion and nutrient runoff. Urban runoff may contain a diversity of contaminants. Urban development increases the percentage of impervious surface areas (i.e. parking lots, rooftops, etc.), thereby reducing rainfall infiltration while increasing runoff. As agricultural lands within the Floyds Fork watershed are converted to urban land use, the water quality of the system will be increasingly influenced by urban nonpoint impacts.

Two landfills are active in the watershed. Smith's Landfill is located near the head of an unnamed tributary to Bluelick Creek in segment 12025. This landfill receives a variety of industrial wastes, including industrial plant solvents and coatings, mixed sealers, adhesives and grease, tank car sludge washings and asbestos containing materials (Kentucky Division of Waste Management (KDWM) data). The Red-Penn Sanitation Company, Incorporated (R-PSCI) landfill is located adjacent to Floyds Fork (MP 46.0) in segment 12027. The extent to which these landfills influence water quality is unknown. The Commonwealth is currently requiring R-PSCI to monitor the landfill for possible leachate seepage into Floyds Fork (KDWM files).

Four quarries are located in the watershed. In segment 12025, two limestone quarries lie along Brooks Run. A third quarry, adjacent to Clear Run, excavates shales of the New Providence series. A shale processing plant is located near this quarry at Hubers-Kenlite Station. A dolomite quarry is located at the head of "lesser" Chenoweth Run in segment 12027. The impact these quarries to the Floyds Fork watershed is unknown.

Stream Uses

According to Schimpeler-Corradino Associates (1975), the principal land use in segment 12025 is agriculture (66%). Additional land uses include forested lands (32%), urban (1.5%), construction (0.3%) and mining (limestone and clay, < 0.2%). The land uses in segment 12026 include agriculture land (49%), urban (46%) and construction (5%). The land uses in segment 12027 are agriculture (67%), forested lands (20%), urban (11%), construction (1.5%) and mining (0.01%). Segment 12028 is largely rural/agricultural (79%) and forested (21%). Construction and mining account for less than 1% of the land uses in this segment. As mentioned in the previous section (Basin Impacts), portions of the Floyds Fork watershed have undergone extensive urbanization during the past 20 years, with future development anticipated in segments 12025, 12026 and 12027. While neither Floyds Fork nor any of its tributaries are currently being used for a public water supply, the stream system is utilized by farmers for irrigation and stock watering.

Floyds Fork has been cited in The Nationwide Rivers Inventory (National Park Service 1982) as having outstanding scenic, recreational, geological and fishery values. Portions of Floyds Fork are utilized for a variety of recreational purposes. The stream is used for canoeing from MP 50.7 (KY 1408 bridge) to the confluence with Salt River (Sehlinger 1978). Floyds Fork also provides wadable and floatable warmwater fisheries for smallmouth and spotted bass (Sehlinger and Underwood 1980), as well as largemouth bass and panfishes (OCSCD 1981). The stream's recreational benefits are of added significance because of its proximity to metropolitan Louisville. Camping facilities are located near the confluence of Floyds Fork with Salt River. Fishing and boating commonly occur in this reach. Hunting for waterfowl, small mammals and deer occurs throughout the watershed in rural areas. These game animals, as well as non-game species, utilize the various streams and adjacent buffer zones for breeding, rearing

young and feeding, as well as a water supply for drinking. Trapping for small mammals such as muskrats, mink, etc. also occurs in rural sections of the drainage.

METHODS

Water and composite sediment samples were collected and analyzed in accordance with the latest edition of Standard Methods for the Examination of Water and Wastewater (APHA 1981) and United States Environmental Protection Agency's (U.S. EPA) Methods for Chemical Analysis of Water and Waste (U.S. EPA 1979). Field turbidity measurements were taken with an HF Instruments Model DRT-15 turbidimeter. Field conductivity was determined with a Yellow Springs Instrument Company (YSI) Model 33 S-C-T meter. Field measurements for dissolved oxygen (DO) and water temperature were conducted with a YSI Model 54A oxygen meter. An Analytical Measurements Model 707B pH meter was used for field pH.

Biological samples were collected utilizing a variety of techniques. Qualitative algal samples were procured by selectively scraping or siphoning material from all available habitats. Samples were preserved in the field with 5% buffered formalin and transported to the Division of Water (DOW) biological laboratory for analysis. Quantitative periphyton samples were collected using floating Design Alliance periphytometers containing glass slides. Exposure periods ranged from 29 to 37 days. Three slides from each periphytometer were analyzed for chlorophyll-a by the the fluorometric method and corrected for phaeophytin (APHA 1981). Ash-free dry weight was analyzed for three replicates of each sample in accordance with APHA (1981). Diatoms were treated with 30% hydrogen peroxide and potassium dichromate to remove organic material (van der Werff 1955), and several slides randomly scanned for the presence of rare taxa.

Macroinvertebrate qualitative samples were taken by selectively picking various substrate types and by collecting in different habitats with a triangular kick net. Quantitative samples were collected by the travel-kick method (a 10 ft. area for 60 seconds) outlined by Hornig and Pollard (1978). All

invertebrate samples were preserved in the field in 70% alcohol solution and transported to the DOW biological laboratory for enumeration and identification. The trophic relationships follow those outlined by Merritt and Cummins (1978) and Hawkins and Sedell (1981). Aquatic macroinvertebrates were placed into one of three pollution categories, (i.e. tolerant, facultative and intolerant), generally based on information presented by Weber (1973) and Hart and Fuller (1974). These categories are defined by Beck (1955) and Weber (1973) as follows: tolerant organisms are associated with gross organic contamination and are generally capable of thriving under anaerobic circumstances; facultative organisms are capable of tolerating a wide range of environmental conditions, including moderate levels of organic enrichment, but cannot exist under anaerobic conditions; intolerant organisms are sensitive to even moderate levels of organic enrichment and are generally unable to withstand even moderate reductions of dissolved oxygen.

Diatom and macroinvertebrate species diversity indices ($\bar{d}$) and equitability (e) were calculated using the procedure described by Weber (1973). Diatom relative abundance, $\bar{d}$ and e were generated by counting a minimum of 500 valves. Macroinvertebrate relative abundance was calculated with the pooled quantitative data.

Fish were collected using a 3.4m by 1.2m, 0.3cm mesh, common sense minnow seine and a Coffelt Model BP-2 backpack shocker. Both pool and riffle areas and all recognizable habitat types were sampled. The fish samples were preserved in 10% formalin solution and transported to the DOW biologiccal laboratory for enumeration and identification. Fish community structure was analyzed using the Index of Biotic Integrity (IBI) method (Karr 1981). Fish for tissue analysis were collected at one site (12027001), and processed according to standard procedures (Benville and Tindle 1970). Analysis was performed at the DES laboratory for the presence of metals and certain organic compounds.

Bacteriological samples were collected from directly below the water's surface in 250 ml, wide mouth, nalgene jars, placed on wet ice and returned for analysis to the DOW biological laboratory within six hours. Analyses for fecal coliform and fecal streptococci bacteria were performed using the membrane filters techniques outlined by Bordner et al. (1978).

PHYSICAL EVALUATION

Located in north-central Kentucky, Floyds Fork drains an area of 736 km^2 (284 mi^2) (Bower and Jackson 1981) in portions of Henry, Oldham, Shelby, Jefferson, Spencer and Bullitt counties. The mainstem of Floyds Fork is formed at the confluence of the North and East forks in eastern Oldham County near Ballardsville. Flowing in a southwesterly direction for 99 km (62 mi), the stream reaches its confluence with Salt River at MP 25.5 near Shepherdsville in north-central Bullitt County. The watershed lies largely within the Outer Blue Grass Subsection of the Blue Grass Section of the Interior Low Plateaus Province (Quarterman and Powell 1978). A portion of the watershed, from the confluence of Floyds Fork with Salt River upstream to MP 6.0, including the headwaters of Brooks Run, lies within the Knobs Subsection of the Blue Grass.

Moderate to gently rolling slopes characterize the topography of Outer Blue Grass portions of the watershed, while areas within the Knobs are marked by the presence of more or less conical hills rising above stream terraces (Quarterman and Powell 1978). Watershed elevations range from 121.9 m above mean sea level (msl) at the mouth to approximately 274 m above msl along the Harrods Creek-Little Kentucky River divide. Several of the Knobs approach or exceed elevations of 274 m.

The portion of the watershed within the Outer Blue Grass is underlain by shale and limestone of the Maysville and Richmond groups of Ordovician and Silurian age, and limestone of Devonian age (Hendrickson and Krieger 1964). A rolling topography has been produced in the Outer Blue Grass as a result of the more shaley nature of the limestone. Karst topography in the Outer Blue Grass is poorly developed, with most of the drainage being on the surface (Palmquist and Hall 1961). Outcrops within the Knobs are principally of Ohio shale (upper Devonian black shale) and New Providence and Waverly (lower Mississippian) shales and sandstones (Schimpeler and Corrandino, 1975).

Major soil series in the Floyds Fork watershed include the Lowell-Shelbyville-Fairmont association of the Outer Blue Grass and the Colyer-Rockcastle-Otway-Tyler-Purdy series in the Knobs (Bailey and Winsor 1964). Slopes associated with soil series in the Outer Blue Grass range from 3 to 35% and drainage may be described as somewhat excessive (Fairmont) to well drained (Lowell-Shelbyville). Slopes associated with soil series in the Knobs range from 4 to 50% in upland areas to 0 to 4% on the stream terraces. Drainage of upland soils (Colyer-Rockcastle-Otway) is somewhat excessive, while stream terrace soils (Tyler-Purdy) are poorly drained. Potential sediment runoff is considered low in areas of less than 6% slope, medium with 6 to 20% and high in areas of over 20% slope (Schimpeler and Corradino, 1975).

Flow data for Floyds Fork, as measured at the USGS gaging station at Fisherville (MP 32.7), are available for the past 37 years (USGS 1981). Average discharge of Floyds Fork at this site was 5.041 m^3/s (178 ft^3/s) for the period of record. Maximum discharge for the period of record was 507 m^3/s (28,500 ft^3/s) on April 2, 1970. Periods of no flow occur in most years. Flow data, as measured at the USGS gaging station at Crestwood (MP 50.7), are available for the past three years. Average discharge at this site was 1.003 m^3/s (35.4 ft^3/s) with a maximum discharge of 39.365 m^3/s (1,390.0 ft^3/s) on June 10, 1981 (USGS 1981). Average stream gradient is 1.3 m/km (7.0 ft/mi) (Schimpeler and Corradino, 1975). Table 3 presents average gradient and seven day, ten year low flow (7Q10) values by segment.

Table 3: Mainstream Length, Average Gradient and 7Q10 Values by Segment for the Floyds Fork System

Segment	Mainstream Length	Average Gradient	7Q10
12025	38.6 km (24 mi)	0.7 m/km (3.5 ft/mi)	0.0 m^3/s (0.0 cfs)
12026	13.7 km (8.5 mi)	3.4 m/km (18.0 ft/mi)	0.0 m^3/s (0.0 cfs)
12027	33.8 km (21.0 mi)	1.1 m/km (6.0 ft/mi)	0.0 m^3/s (0.0 cfs)
12028	20.9 km (13.0 mi)	3.2 m/km (17.0 ft/mi)	0.0 m^3/s (0.0 cfs)

Data taken from Schimpeler and Corradino (1975)

A diversity of habitats exists throughout the Floyds Fork system. Both pools and riffles were common, the ratio varying according to location. Numerous rock ledges, shoals, brush covered islands, log piles, gravel bars, undercut banks, submerged logs and roots, as well as a variety of substrates, were also noted. Riparian zones were generally well developed and diverse. This vegetation provides shade, sediment and nutrient control, bank stabilization as well as food and cover for fish, invertebrates and wildlife. Some studies indicating the importance of riparian buffer zones to the fauna and water quality of streams include Karr and Schlosser (1977), Karr and Schlosser (1978), Nelson et al. (1978), Schlosser and Karr (1981a), Schlosser and Karr (1981b) and USDA (1978).

Floyds Fork

Station 12025001 (25-1)

This station, located on Floyds Fork (MP 1.4) in Bullitt County, was 1.6 km (1.0 mi) upstream of the Ky 44 bridge (Figure 1). The stream is fifth order with moderate gradient. Pools varied from 12.2 to 18.3 m (40 to 60 ft) in width and 0.15 to 1.1 m (0.5 to 3.5 ft) in depth. Pool substrate consisted primarily of sand and silt overlain by leaf litter and scattered boulders. Riffles varied from 9.1 to 15.2 m (30 to 50 ft) in width and 0.1 to 0.18 m (0.3 to 0.6 ft) in depth. Riffle substrate consisted primarily of sand with some gravel, pebble, cobble and scattered boulders. Moderate amounts of sedimentation were noted, with little or no substrate imbeddedness. Stream habitats included gravel bars, undercut banks, rock ledges, submerged tree roots, logs, boulders and a variety of substrates. Moderate amounts by periphyton were attached to the substrates and plant litter. Hydraulic obstructions in the stream included drift piles, large boulders and gravel bars.

Stream banks were steep, 6.1 to 9.1 m high and tree lined. Lower bank areas were covered with herbaceous vegetation and tree roots. The diverse

flora and associated root systems provides stability to the stream banks, as well as habitat for fish and wildlife. The line of hardwoods was more than 30.5 m wide along the west bank, and varied from 15.2 to 24.4 m along the east bank, before reaching farm pastures. Potential nonpoint source contributors were farm fields, scattered dwellings and an area (approximately 0.8 h) of exposed soil. A fishing camp was noted downstream. The buffer zone of 70% trees, 15% shrubs and 15% herbaceous vegetation would partially mitigate the runoff from these areas.

A 50 to 75% canopy was formed over the stream by numerous hardwood species. Some of the common trees noted were sycamore (Platanus occidentalis), silver maple (Acer saccharinum) and American beech (Fagus grandifolia). Duckweed (Lemna minor), the floating aquatic macrophyte, was present in pool and backwater areas.

Floyds Fork

Station 12025002 (25-2)

This station was located at the Fairmount Road ford on Floyds Fork (MP 21.0) in Jefferson County (Figure 1). The stream is fifth order and of moderate gradient. Pool width ranged from 15.2 to 24.4 m (50 to 80 ft) with depths from 0.2 to 0.24 m (0.3 to 0.8 ft). Pool substrate was primarily bedrock overlain with fines and detritus and some areas of cobble-pebble with scattered boulders. Riffle width varied from 3.0 to 9.1 m (10 to 30 ft) with depths from 0.05 to 0.15 m (0.1 to 0.5 ft). Riffle substrate types were primarily cobble-pebble with scattered boulders. Slight sedimentation was noted, with no imbeddedness of the substrate. Aquatic habitats included undercut banks, rock ledges, gravel bars, submerged tree roots and logs, as well as a variety of substrates. Dense growths of periphyton were attached to the substrates and plant litter. Hydraulic obstructions in the stream included log piles, gravel bars and boulders.

The riparian vegetation consisted of 70% trees, 15% shrubs and 15% herbaceous plants. The diverse flora and associated root systems provides stability to the upper and lower stream banks, as well as habitat for fish and wildlife. Only slight erosion was noted within the sample area. The east and west banks were similar in morphology, being tree lined, 1.8 to 2.4 m (5.0 to 8.0 ft) in height and varying in degrees of slope. Corn fields bordered the buffer zone to the east and farm pastures to the west. Streamside vegetation would filter a portion of the sediment load entering Floyds Fork.

Hardwoods provided little shade (25 to 50% canopy) over the water, which contributed to the dense growth of periphyton noted earlier. Tree species included sycamore (Platanus occidentalis), hackberry (Celtis occidentalis), silver maple (Acer saccharinum), honey locust (Gleditsia triacanthos), green ash (Fraxinus pennsylvanica), boxelder (Acer negundo) and American elm (Ulmus americana).

Chenoweth Run

Station 12026001 (26-1)

This station was located on Chenoweth Run (MP 0.2) at Seatonville Road, in Jefferson County (Figure 1). The stream is third order and of moderate gradient. Pool width varied from 12.2 to 18.3 m (40 to 60 ft) with depths from 0.15 to 0.9 m (0.5 to 3.0 ft). Riffle width ranged from 4.6 to 6.1 m (15 to 20 ft) with depths from 0.05 to 0.15 m (0.1 to 0.5 ft). Pool and riffle substrates were primarily bedrock, with some silt, sand, gravel, pebble, cobble and boulders. Slight sedimentation was noted, with no substrate imbeddedness. Stream habitats included undercut banks, gravel bars, submerged tree roots and logs, as well as a variety of substrates. Hydraulic obstructions in the stream included a bridge abutment, log piles, gravel bars and scattered large boulders.

The riparian buffer zone consisted of 70% trees, 10% shrubs and 10% herbaceous plants, with approximately 10% of the bank area exposed (primarily the

lower bank). Trees lining the stream provided bank stability. Root mats were well developed and often extended into the water, providing fish and wildlife habitat. Only slight erosion was noted in the sampling area. Pastures and tilled fields bordered both riparian zones. Other potential contributors to non-point source runoff included Seatonville Road and some scattered dwellings. Streamside vegetation would filter a portion of the sediment load before it entered Chenoweth Run.

Hardwoods provided little shade (25 to 50% canopy) over the stream. This aided in the development of a dense growth of algae. Tree species included sycamore (Platanus occidentalis), silver maple (Acer saccharinum) and boxelder (Acer negundo).

Floyds Fork

Station 12027001 (27-1)

This station was located 2.4 km (1.5 mi) south of the confluence with Pope Lick Creek (MP 31.1) in Jefferson County (Figure 1). The stream is fifth order with moderate gradient and consists of one long pool with a series of riffles and gravel bars. Pool width varied from 9.1 to 24.4 m (30 to 80 ft) with depths of 0.15 to 0.76 m (0.5 to 2.5 ft). Pool substrate was primarily bedrock overlain by silt to cobble size materials and some leaf litter. Riffle width ranged from 3.1 to 9.1 m (10 to 30 ft) with depths from 0.05 to 0.15 m (0.1 to 0.5 ft). The riffle substrate was mainly cobble-pebble, with scattered boulders, gravel and sand.

Moderate amounts of sedimentation, partially the result of some stream dredging (0.5 km upstream) and agricultural runoff, were noted. There was little or no imbeddedness of the substrate. Stream habitats included undercut banks, gravel bars, submerged roots and stumps and a variety of substrate types. Hydraulic obstructions in the stream included drift piles, numerous gravel bars and scattered large boulders. Dense growths of water willow (Justicia americana) were common in the shallow water areas of the stream.

Riparian vegetation consisted of 70% trees, 15% shrubs and 15% herbaceous plants. A 25 to 50% tree canopy provided some shade over the water. Dominant hardwoods lining the banks were sycamore (Platanus occidentalis) and silver maple (Acer saccharinum). Well-developed root systems stabilized the banks and provided fish and wildlife habitat. Very little erosion was noted. Stream banks were steep and three to seven meters high. Pope Lick Road parallels the stream beyond the west bank. Potential nonpoint sources of runoff included bordering farm pastures and tilled fields, a roadside dump, scattered houses and Pope Lick Road. Streamside vegetation would help to reduce sedimentation impacts from surface runoff.

Floyds Fork

Station 12028001 (28-1)

This station was located just downstream of the KY 1408 Bridge (MP 50.7) on the Oldham - Shelby County line (Figure 1). The stream is fifth order, with moderate gradient and consisted of long pools and a series of riffles and gravel bars. Pool width varied from 12.2 to 18.3 m (40 to 60 ft) with depths of 0.15 to 0.9 m (0.5 to 3.0 ft). Pool substrate was bedrock, with a layer of fines in depositional areas. Riffle width ranged from 3.1 to 7.6 m (10 to 25 ft) with depths from 0.05 to 0.10 m (0.1 to 0.3 ft). The riffle substrate was predominately cobble-boulder with some pebble, gravel and fines. Sedimentation had resulted in 75% of the pool substrate being imbedded. Riffles were unimbedded. Stream habitat included undercut banks, gravel bars, submerged roots and logs and a variety of substrates. Beds of water-willow (Justicia americana) were noted in the shallow water areas of the stream. Hydraulic obstructions included log piles and gravel bars.

Riparian vegetation was dominated by trees (80%), with some shrubs (10%) and herbaceous plants (10%). Both banks were six to eight meters high and

steep. A narrow buffer zone existed beyond the south bank before reaching an old field. To the north, the wooded zone was better developed and bordered by a cornfield. The stream was partially shaded by a 50 to 75% tree canopy. Noted tree species were sycamore (Platanus occidentalis), boxelder (Acer negundo), hackberry (Celtis occidentalis), silver maple (Acer saccharinum), and osage orange (Maclura pomifera). Root systems were well developed and the banks appeared stable. The presence of these root systems provides habitat for fish and wildlife. Very little erosion was noted. Potential nonpoint source contributors included farm fields and a jeep trail. Streamside vegetation would filter some sediments from surface runoff.

Currys Fork

Station 12028002 (28-2)

This station was located at the KY 1408 bridge in Oldham County at MP 0.4 (Figure 1). The stream is fourth order with moderate gradient and alternates between riffles and pools. Gravel bars were scattered throughout. Bedrock was the predominant substrate, with boulders, cobble and gravel also present. Leaf litter overlaid the substrate in some areas. Maximum stream width was 12.8 m (42 ft). Water depth varied from 0.1 to 0.61 m (0.3 to 2.0 ft). Sedimentation had resulted in approximately 25% of the substrate being imbedded. Stream habitats included gravel bars, beds of water-willow (Justicia americana) and a variety of substrates. Hydraulic obstructions included large boulders, gravel bars and a bridge abutment.

The riparian zone consisted of 50% herbaceous vegetation and only 30% trees and 20% shrubs. The tree canopy (25% to 50%) provided little shade. This aided in the development of a dense periphyton growth. Both banks were steep and 3 to 5m high. Well-developed ground cover was primarily responsible for stabilizing the upper and lower bank areas. Very little erosion was noted. Pastures

and tilled fields bordered the buffer zones. These areas, along with KY 1408, were potential nonpoint source contributors. Filtration by streamside flora would reduce the amount of sediments entering the stream.

North Fork Currys Fork

Station 12028003 (28-3)

This station was located at the KY 393 bridge in Oldham County at MP 6.7 (Figure 1). The stream is third order with moderate gradient and consisted of long pools with occasional riffles and gravel bars. Pool width varied from 3.0 to 9.1 m (10 to 30 ft) with depths of 0.1 to 0.5 m (0.3 to 1.5 ft). Pool substrate was primarily bedrock overlain by detritus, with some areas of boulder, cobble and pebble materials. Riffle width ranged from 1.2 to 6.1 m (4 to 20 ft) with depths from 0.03 to 0.1 m (0.1 to 0.3 ft). The riffle substrate was predominantly pebble-gravel. Slight sedimentation was noted, but no substrate imbeddedness was observed. Stream habitats included gravel bars, submerged roots, occasional undercut banks and a variety of substrates. Hydraulic obstructions included scattered large boulders, gravel bars and a bridge abutment.

The riparian buffer zone consisted of 60% trees (mainly saplings), 30% shrubs and 10% herbaceous plants. Both stream banks were low (0.6 to 1.2 m), tree lined and well stabilized. Root systems extended over the lower bank and into the water, providing fish and wildlife habitat. Dense algal growths in the water were the result of the partially shaded (25 to 50% canopy) nature of the stream. Streamside vegetation extended approximately 6.1 m (20 ft) back from the west bank and 6.1 to 18.3 m (20 to 60 ft) beyond the east bank before reaching old fields. North Fork of Currys Fork flows parallel to Interstate 71, between the north and south lanes from MP 6.0 to MP 10.4, which includes the sample site. Other potential nonpoint source contributors include farm fields and KY 393. Sediment entrapment by the streamside flora would help to reduce this impact to the stream

during periods of surface runoff. Hardwoods noted were sycamore (Platanus occidentalis), silver maple (Acer saccharinum), hackberry (Celtis occidentalis) and boxelder (Acer negundo).